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RESPONSE OF SUNFLOWER TO DIFFERENT TILLAGE SYSTEMS AND FOLIAR APPLICATION OF POTASSIUM UNDER WATER DEFICIT CONDITIONS

Muhammad Maqsood[1], Muhammad Umer Chattha[1], Muhammad Umair Hassan[1], Imran Khan[1], Muhammad Bilal Chattha*[2], Muhammad Usman[3], Asif Iqbal[1] and Muhammad Jawad[1]

[1]*Department of Agronomy, University of Agriculture, Faisalabad, Pakistan 38040*
[2]*Institute of Agricultural Sciences, University of the Punjab, Pakistan*
[3]*Department of Agronomy, Bahauddin Zakariya University, Multan, Pakistan*
Corresponding Author: bilal1409@yahoo.com

ABSTRACT

The study was conducted to determine the role of potassium nutrition in improving the productivity of sunflower under different tillage systems with varying water deficit levels. The experiment comprised of tillage systems, i.e., conventional, minimum and zero tillage and water deficit levels (75 mm and 55 mm) with foliar sprays of water, 0.5% and 1% potassium. The results revealed that tillage systems and foliar application of potassium under normal and water deficit conditions appreciably improved the growth and yield of sunflower. Conventional tillage produced maximum increase in growth and yield of sunflower as compared to minimum and zero tillage. Similarly, the application of potassium improved the growth and yield of sunflower both under normal and water deficit conditions. However, the maximum improvement in yield was recorded with foliar spray of 1% potassium under normal conditions, meanwhile the application of 1% potassium under water stress conditions also substantially diminish the negative effects and increased the crop yield. In conclusion, foliar application of 1% potassium can be opted both under normal and water deficit conditions for increasing the productivity of sunflower.

Key Words: Water deficit, sunflower, tillage, yield

INTRODUCTION

Sunflower has 4th position in oil seed production around the globe (FAO, 2000). Moreover, it is economically viable crop, in addition, it also has high adaptability and less labor and input requirements. Pakistan facing the severe deficiency of edible oil and every year we spend a huge amount on the import of edible oil. The ever green population and urbanization created the endless gap between the supply and demand on edible oil. Currently, Pakistan indigenously produced 0.546 million tons (23.38%) edible oil each year, further, country also imports 1.79 million tons (76.62%) edible oil from the other countries. The money used on the import of oil puts high pressure on the national economy. During, fiscal year of 2014-15, government spent a huge amount of 139.344 billion rupees on the import of edible oil. Therefore, this alarming situation warrants us to enhance the local production of oil seed crops (Govt. of Pakistan, 2015).

Major constrains that can reduce productivity of sunflower are, improper tillage practices, seed quality, unavailability of water and fertilizers, and lack of proper production technology packages. Tillage plays a substantial role in crop production; however, its advantages and disadvantages can vary among tillage systems. Likewise, conventional tillage increased the crop yield however, it also has few unfavorable effects, like, it creates soil compaction and it also results a substantial increase in cost of production (Armstrong *et al*., 2003). Conversely, minimum or zero tillage improved the soil properties; however, it did not significantly increase the crop yield as compared to conventional tillage (Gibson *et al*., 1992). Moreover, Hassan *et al.* (2003), reported that zero or minimum tillage is not suitable for the certain soils and crops. Similarly, Jan *et al.* (2010) found that conventional tillage is helpful in controlling the weeds and it also substantially improves the grain yield as compared to the no tillage.

Water scarcity is a major abiotic stress that is severely affecting the crop productivity around the globe (Shahbaz *et al*., 2011). Sunflower crop often considered as drought resistance, but increase in water deficiency substantially decreased its growth, yield and oil productivity (Iqbal *et al.,* 2005). Likewise, Souza et al., (2004) also reported that drought stress reduced growth, yield and yield components sunflower. Several approaches can be used to improve crop growth and yield of crops under water deficit conditions. Crop breeding is a key approach that contributes significantly towards the successful crop production, but it is time consuming (Ashraf *et al.*, 2006). The screening of available cultivars against the drought stress could be another promising approach for successful crop production under water deficit conditions (Ashraf *et al.*, 2006). The foliar application of nutrients could be another promising technique to increase crop production under drought stress. Like, drought stress substantially reduces the nutrient uptake and translocation, therefore, the foliar application of nutrients may be an attractive approach to improve the crop performance under water deficit conditions.

The application of potassium regularizes the various processes under drought stress, like, photosynthesis, cation transformation from source to sink, maintenance of turgor pressure and enzymatic activities (Mengel and Kirkby, 2001). Likewise, Cox, (2001) reported that potash improved the root growth and therefore, enhanced the plants ability to absorb water from soil thus increased the resistance capacity against drought that finally increased the growth and yield under drought stress. The foliage feeding of potassium appreciably increased growth and productivity of crops under water limited conditions (Egilla *et al.*, 2001). The negative effects of drought on crops can be diminished by the supply of potash (Sangakkara *et al*., 2000), moreover, low yield resulting from drought stress can be overcome by the application of potassium (Damon and Rengel, 2007). Realizing the importance of potassium against the drought, an attempt has been made to mitigate the water stress effects on sunflower crop through foliar spray of potassium under different tillage systems.

MATERIALS AND METHODS

Experimental site, soil and weather conditions

The experiment was carried out at Student Farm, Department of Agronomy, University of Agriculture, Faisalabad, during the spring season of 2015. For soil analysis the composite soil samples were taken from the depth of 0-20 cm with the help of augar. The collected soil samples were analyzed by using standard procedures advised by Homer and Pratt (1961). The experimental soil was sandy clay loam, having pH (7.6), EC (1.27 dS m^{-1}), organic matter (0.95%), available nitrogen (0.079%), available phosphorus (16.8 ppm) and available potash (43 ppm), respectively. The study site comes under semi-arid region, further, weather data during the experimental period is given in Table 1.

Table 1. Prevailing climatic conditions of the experimental site during crop growing seasons for the year 2015.

Months	**Monthly Mean Max. Temp (°C)**	**Monthly Mean Min. Temp (°C)**	**Monthly Avg. Temp (°C)**	**R.H (%)**	**Rainfall (mm)**
Feb-2015	22	11.1	16.5	66	20.5
Mar-2015	24.5	13.6	19.1	64	67.9
Apr-2015	33.2	20.7	27	43.9	32.8
May-2015	38.7	24.9	31.8	27.5	17
Jun-2015	25.6	31.8	39	11.6	38

Planting material and experimental treatments

The seeds of sunflower hybrid Hysun-33 were collected from Oil Seed Section, Ayub Agriculture, Research Institute, Faisalabad. The experiment consisted of different tillage systems, i.e., CT = conventional tillage, MT = minimum tillage, ZT = zero tillage and water deficit and potassium sprays, i.e., T1 = control (75 mm) + water spray, T2 = water deficit (55 mm) + water spray, T3 = control (75 mm) + 0.5% K_2O spray, T4 = water deficit (55 mm) + 0.5% K_2O spray, T5 = control (75 mm) + 1% K_2O spray and T6 = water deficit (55 mm) + 1% K_2O spray. A measured quantity of water was applied by manual labor with the help of a fountain bucket fitted with a shower. The calculation for required amount of water for a depth of 55mm and 75mm were made as given below.

Amount of water for 55mm depth of irrigation

Plot area = 3m × 6m = $18m^2$
Depth of irrigation = 55mm = 0.055m
Volume of water required = $18m^2$ × 0.055m = $0.99m^3$
Fountain diameter (d) = 24cm
Radius (r) = 12cm = 0.12m
Length of bucket (L) = 26cm = 0.26 m
Volume of fountain bucket = Area × Length
Area = $\pi r^2 = 3.14 \times (0.12)^2 = 0.0452\ m^2$
Volume of bucket = Area × Length = 0.0452 × 0.26 = 0.01175 m^3
Number of fountain buckets required for water application per plot is calculated as:

Total water required / volume of bucket = 0.99 / 0.01175 = 84.26 buckets plot^{-1}

Amount of water for 75mm depth of irrigation
Plot area = 3m × 6m = 18m^2
Depth of irrigation = 75mm = 0.075m
Volume of water required = 18m^2 × 0.075m = 1.35m^3
Volume of bucket = 0.01175 m^3
Number of fountain buckets required for water application per plot is:
Total water required / volume of bucket = 1.35 / 0.01175 = 114.8 buckets plot^{-1}

Crop husbandry

A pre-soaking irrigation of 10 cm was applied before seedbed preparation. In minimum and conventional tillage, soil was ploughed 1 and 3 times with tractor mounted cultivator each followed by planking, while in zero tillage soil was not ploughed. NPK fertilizers were applied at the rate of 150:98:62 kg ha^{-1} in the form of urea, diammonium phosphate, and sulphate of potash respectively. Half of the nitrogen and full dose phosphorus and potash were applied as basal dose, while the rest of nitrogen was applied with first irrigation.

Data recording

Total number of plants from each plot was calculated to determine the plant population. Similarly, ten plants selected at random to determine the plant height, stem diameter, head diameter and achenes per head. At the end crop was harvested and sun dried in the field to determine the biological yield and later on trashed with Sheller. A sub sample of 1000 grains was taken from the seed lot to determine the 1000 grain weight. Similarly, the yield of all the harvested plots was measured and later converted to hectare basis. Harvest index was measured using the formula, HI= (Grain yield/Biological yield) × 100. The collected seed samples were subjected to chemical analysis for determination of seed oil contents (AOAC, 1990).

Experimental design and data analysis

The study was carried out in Randomized Complete Block Design (RCBD) in split plot arrangement with three replication. The net plot size for was 3 m × 6 m. Collected data was analyzed statistically by using Fisher's analysis of variance technique and treatment's means were compared by least significant difference (LSD) at 5% probability level (Steel *et al.,* 1997).

RESULTS

The results revealed that tillage systems and foliage feeding of water and potassium under water deficit conditions considerably influenced the growth and yield attributes of sunflower. Tillage systems significantly influenced the plant height and plant population (Table 2). The tallest plants (179.12 cm) and maximum plant population per plot (93.04) was recorded with conventional tillage, while, the smaller plants (167.75 cm) and less plant population (83.22) was found in zero tillage plots (Table 2). Meanwhile, the foliar spray of potash under water deficit conditions markedly increased the plant height, but had no significant effect of the plant population. The maximum plant height (177.13 cm) was recorded under control conditions with foliage feeding of 1% K_2O (Table 2), while the minimum plant height (171.99 cm) was recorded under water deficit of 55 mm with foliar spray of water (Table 2).

Similarly, the tillage systems and foliar sprays of water and potash under various water deficit conditions significantly influenced the head diameter but had non-significant effect on stem diameter (Table 2). The maximum head diameter (16.35 cm) was recorded in conventional tillage plots, whereas minimum head diameter (14.77 cm) was recorded with zero tillage. Regarding the water deficits, the maximum head diameter (16.99 cm) was founds in plots having 75mm deficit and treated with 1% potash spray (Table 2). Meanwhile, tillage systems and foliar sprays also behaved significantly for the achenes per head and 1000 achence weight. The maximum achences per head (1201.1) and 1000 achene weight (63.45 g) was recorded in conventional tillage, however, it was at par with minimum tillage, while lowest achenes (968.2) and 1000 grain weight (51.88) was observed in zero tillage plots. Regarding the water deficits, the maximum achenes (1311.1) and 1000 grain weight (63.42 g) was found in control conditions with foliage feeding of 1% potassium (Table 2), moreover the minimum achenes per head and 1000 grain weight was found in plots having 55 mm deficit and foliar spray of water.

Table 2. Influence of tillage systems and foliar application of water and potassium under water deficit conditions.

	Plant height (cm)	Plant population per plot	Head diameter (cm)	Stem diameter (cm)	Achenes per head	1000-achene weight	Biological yield (kg ha^{-1})	Achene yield (kg ha^{-1})	Harvest index %	Oil contents %
Tillage systems										
CT	179.12 A	93.04 A	16.35 A	1.65	1202.1 A	63.45 A	10815 A	3137.2 A	29.03 A	40.52
MT	178.37 A	92.81 A	16.09 A	1.66	1196.7 A	62.39 A	10883 A	3083.5 A	28.34 A	40.53
ZR	165.75 B	83.22 B	14.77 B	1.60	968.2 B	51.88 B	10232 B	2286.7 B	22.35 B	40.52
LSD (P ≤0.05)	**1.02**	**3.74**	**1.96**	**NS**	**6.90**	**1.50**	**163.56**	**109.21**	**1.22**	**NS**
Water deficit and foliar sprays										
T_1	175.58 A	90.48	15.73 B	1.66	1124.2 B	60.44 B	10704 B	2862.9 BC	26.52	41.02
T_2	171.99 C	89.77	14.62 C	1.61	1097.8 D	54.81 D	10209 D	2725.9 D	26.67	40.04
T_3	175.38 AB	90.46	16.53 A	1.66	1128.7 AB	62.42 A	10915 A	2913.5 AB	26.62	41.13
T_4	172.82 C	90.13	14.75 C	1.61	1117.4 C	56.89 C	10469 C	2796.9 C	26.65	39.95
T_5	177.13 A	88.15	16.99 A	1.67	1131.1 A	63.42 A	10980 A	2922.8 A	26.54	41.12
T_6	173.57 BC	89.77	15.42 B	1.63	1118.5 C	57.47 C	10582 BC	2805.5 C	26.43	39.93
LSD (P ≤0.05)	**1.96**	**NS**	**0.58**	**NS**	**4.51**	**1.34**	**175.82**	**63.86**	**NS**	**NS**
TS×WDAFS	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Means sharing the same letter for a single parameter do not differ significantly at $P \leq 0.05$.

CT= Conventional tillage; MT= Minimum tillage; ZR= Zero tillage; T_1 = control (75 mm) + water spray; T_2 = water deficit (55 mm) + water spray; T_3 = control (75 mm) + 0.5% K_2O spray; T_4 = water deficit (55 mm) + 0.5% K_2O spray; T_5 = control (75 mm) + 1% K_2O spray and T_6 = water deficit (55 mm) + 1% K_2O spray. TS= Tillage systems; WDAFS= Water deficit and foliar sprays; NS = Non-significant

Tillage systems and sprays of potassium under water deficit conditions remarkably improved the biological yield, grain yield and harvest index. Convention tillage registered an increase of 5.70%, 37.19% and 29.88% in biological yield, grain yield and harvest index over the zero tillage. Similarly, foliage feeding of 1% potash under control conditions reported an increase of 7.02% and 7.22% in biological and grain yield over the water deficit of 55mm with water spray (Table 2). However, foliar spray of water and potash had non-significant effect on the harvest index. Similarly, all the tillage systems and foliar sprays of water and potash under various water deficits behaved non-significantly for achene oil contents (Table 2).

DISCUSSION

In this study, conventional tillage improved the plant population and plant height, similarly, foliar application of potash also improved the plant height, while had non-significant effect on the plant population. Conventional tillage improved the soil porosity, nutrient distribution in soil and resulted in fine seed bed Borghei *et al*. (2008) and Wasaya *et al.* (2011) and thereby improved the plant height and plant population (Table 1). The increase in plant height by potassium nutrition under normal and water stress condition can be due improvement in enzymatic activities, higher photosynthesis, and translocation of photosynthes form source to sink. This increase in plant height with K application is a settlement with the work of previous scientist Hussain *et al.* (2008) who reported that potassium application has positive effect on the growth and yield contributing traits of sunflower. Conventional tillage substantially improved the stem and head diameter (Table 2). Conventional tillage improved the seed bed, root growth and nutrient uptake, thereby, resulted in profound increased in stem and head diameter. Similarly, Aikins *et al.* (2012) also reported maximum improvement in stem and head diameter with conventional tillage. Similarly, the foliar application of improved the head diameter, but had no considerable effect on the stem diameter. The potassium nutrition under water deficit conditions improved the cell division, stem extension and vegetative growth, therefore substantially increased the head diameter (Table 2). Likewise, Syers (2001) also found appreciable increase in head diameter with the application of potassium under water scarce conditions.

The convention tillage and foliar application of 1% potash significantly improved the achenes per head, 1000 achene weight, biological yield, grain yield and harvest index (Table 2). The increase in achenes and 1000 grain weight by conventional tillage can be ascribed to fine seed bed, deeper root growth, and better uptake of nutrients that involved in production of more and healthier achenes. This increase in achenes and 1000 grain weight by conventional tillage is in consistence with previous findings of Khurshid *et al.* (2006) and Tahir *et al.* (2011). The conventional tillage improves the soil aeration, nutrient uptake, root growth, which favored the production of more biomass. Similarly, the improved sunflower yield by conventional tillage can be due to combine increase in plant population, yield and yield components. Likewise, Borghei *et al.* (2008) and Wasaya *et al.* (2011) also reported substantial increase in biological and grain yield with conventional tillage. Moreover, the increased harvest can be attributed to combined increase in grain and biological yield.

Similarly, water deficit conditions decreased the yield and yield contributing traits of sunflower (Table 2). Drought stress impaired the root system Hussain *et al.* (2013), which substantially reduced the supply of water and nutrients. Thereby, the poor availability of water and nutrients reduced the crop growth and resulted in less improved yield contributing traits. Similarly, the application of potassium improved the achenes, 1000 grain weight, grain and biological yield (Table 2). The application of potassium developed the root systems and enabled the plants to take more nutrients and water from soil under normal and water stressed conditions, thus improved the growth and productivity. Similarly, Cox, (2001) reported that potash improved the root growth and thus increased the plants ability to absorb the more water and thereby, enhanced the resistance capacity against drought stress. Likewise, the application of potassium increased the photosynthetic rate, plant growth and yield under water limited conditions (Egilla *et al*., 2001). Moreover, tillage systems and foliar application of potash under well watered and water deficit conditions had non-significant effect on the oil contents (Table 2). These findings are in consistence with previous results of results of Goksoy *et al.* (2004) who found a non-significant effect on the oil percentage of sunflower.

CONCLUSION

In conclusion, convention tillage substantially improved the growth and yield of sunflower as compared to the minimum and zero tillage. Moreover, water deficit at any level reduced the growth, yield and biomass production of sunflower. However, potassium application under water deficit conditions neutralized the damaging effects of drought and improved the growth and yield.

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